4.2.4 Tritium

Tritium concentrations remained above the 10^{-6} risk concentration from 1954 through 2036 and remained above the MCL from 1954 through 2005. Figure 4-13 illustrates peak aquifer concentrations anywhere in the aquifer and Figure 4-14 compares simulated and measured tritium concentrations in observation wells. Tritium matches measured concentrations better than the other contaminants because it was the transport calibration contaminant and tritium does not chemically interact with the subsurface, thereby eliminating any error from estimating the fractured basalt and HI interbed partition coefficient.
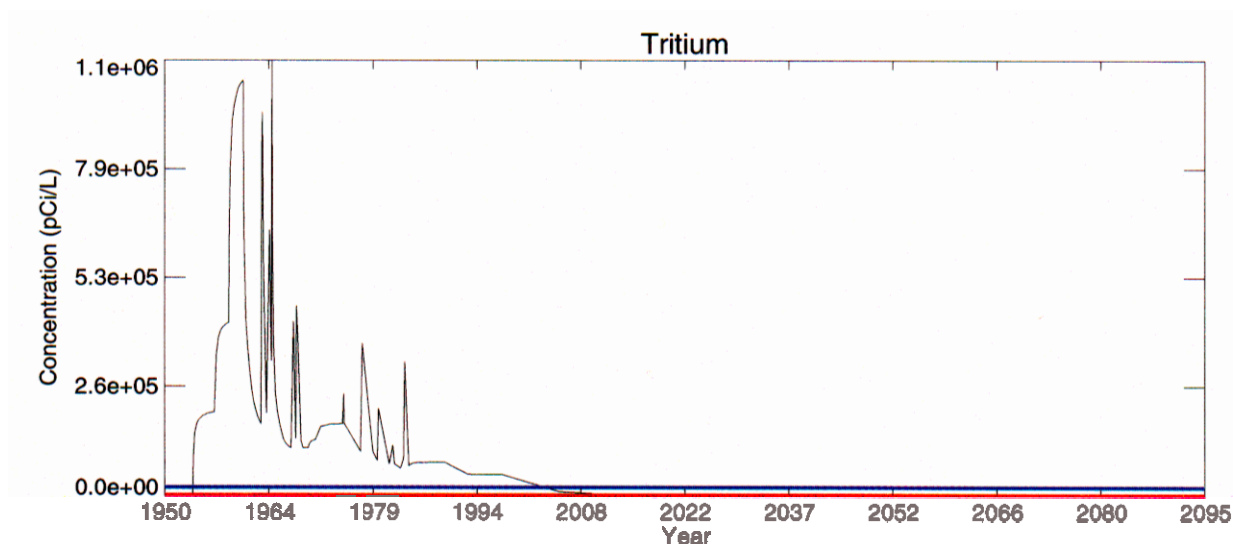

Figure 4-13 Peak aquifer concentration for H-3 (red line is 10^{-6} risk and blue line is MCL concentration).
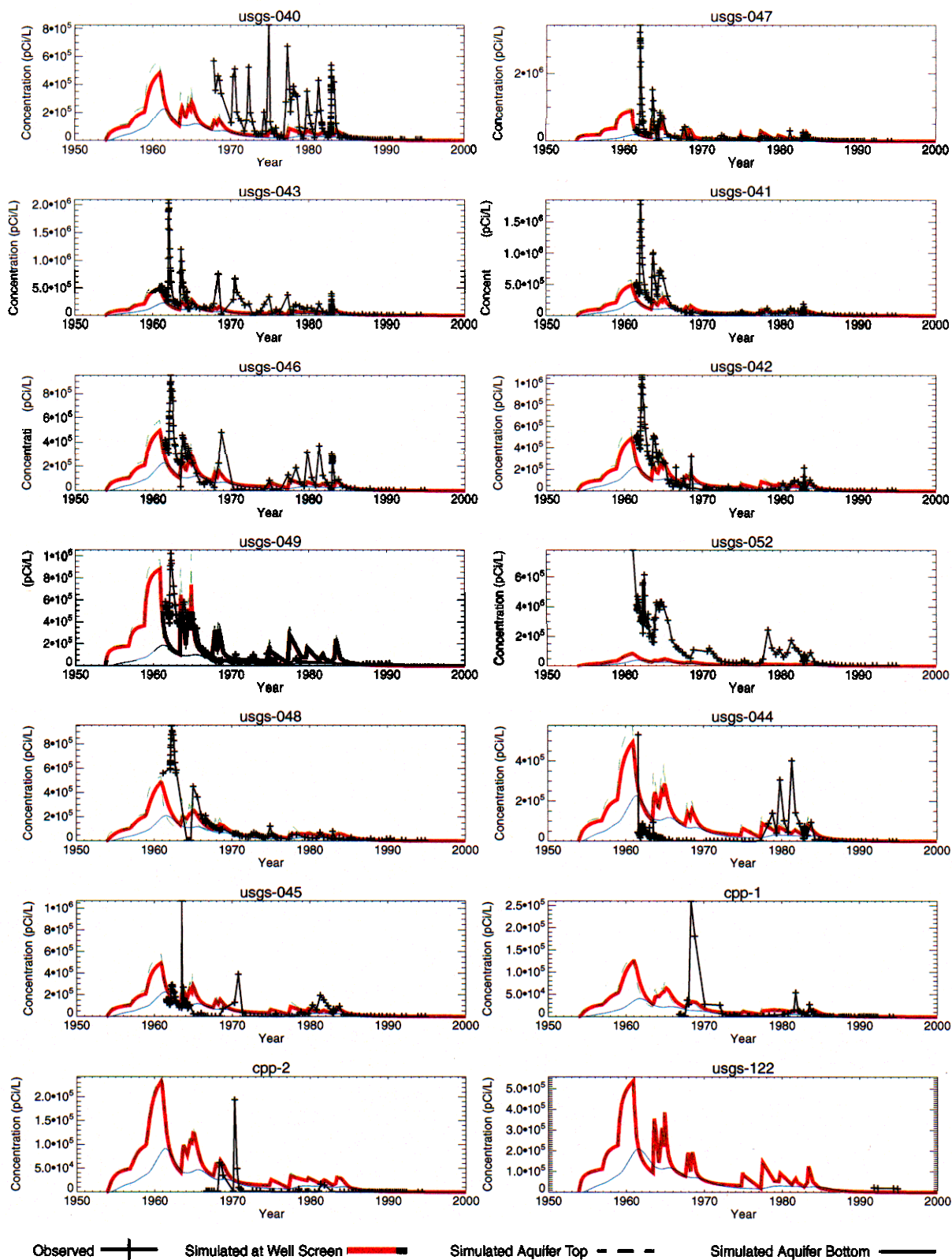
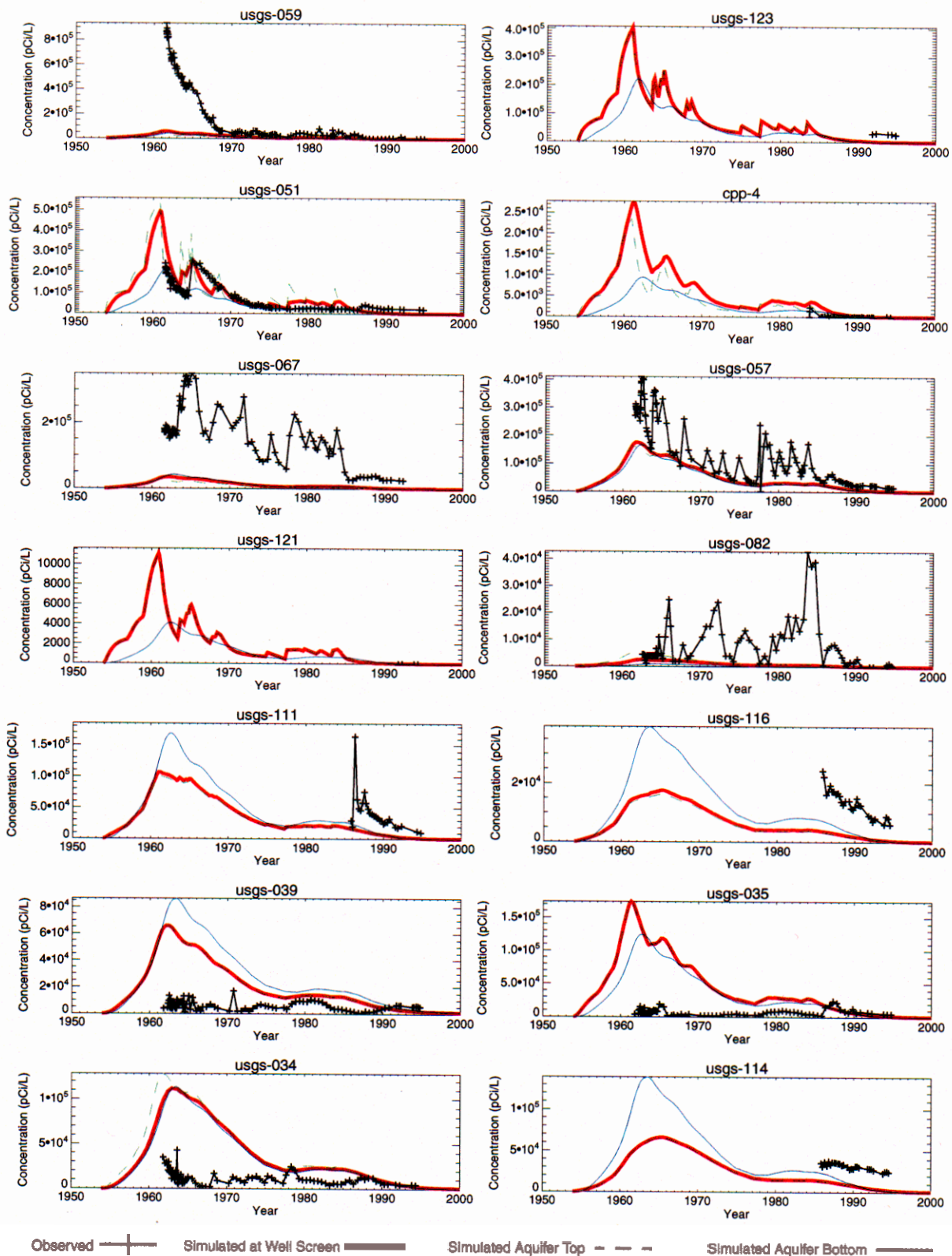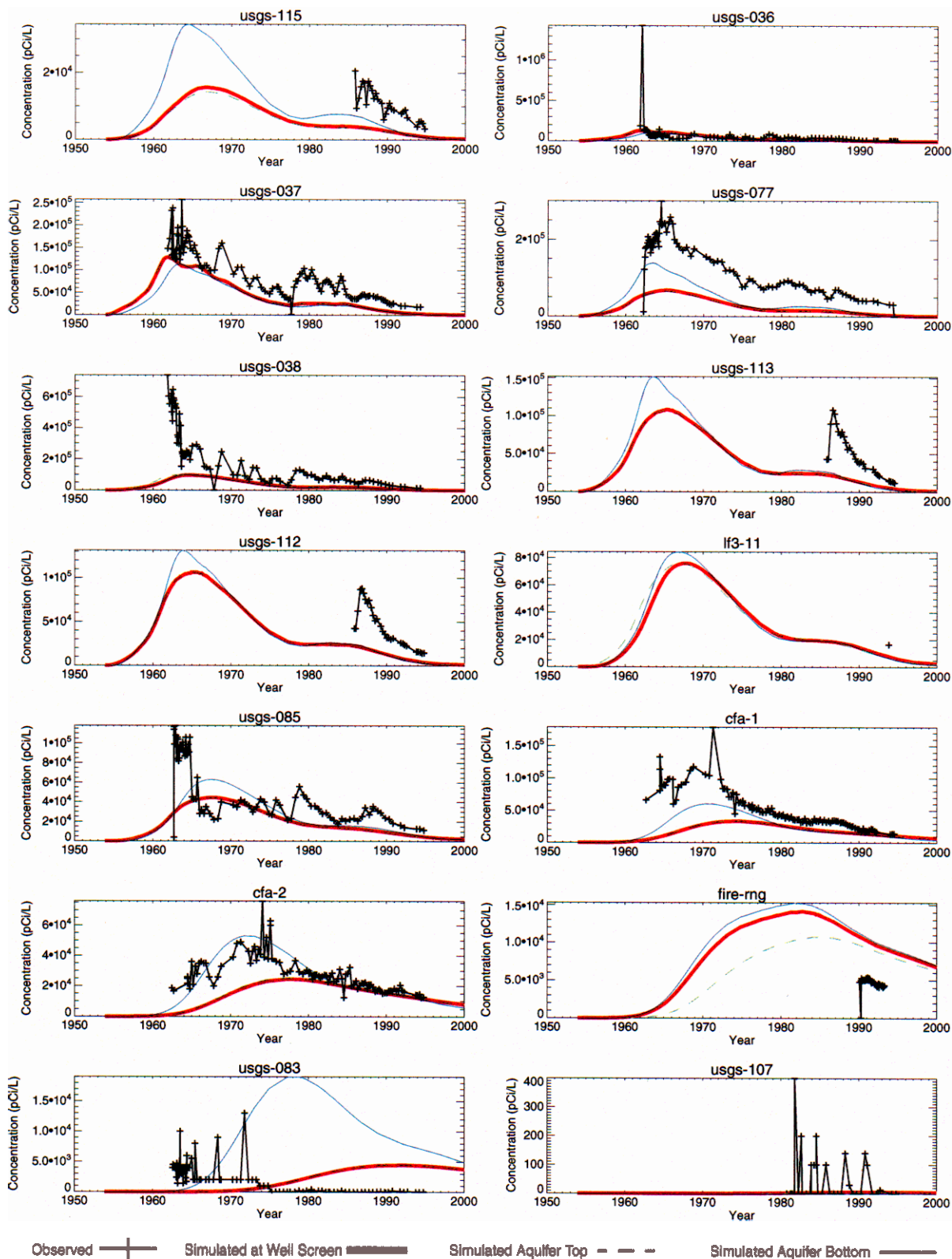**Figure 4-14** Comparison of simulated and measured H-3 concentrations.

Figure 4-14 continued Comparison of simulated and measured H-3 concentrations.

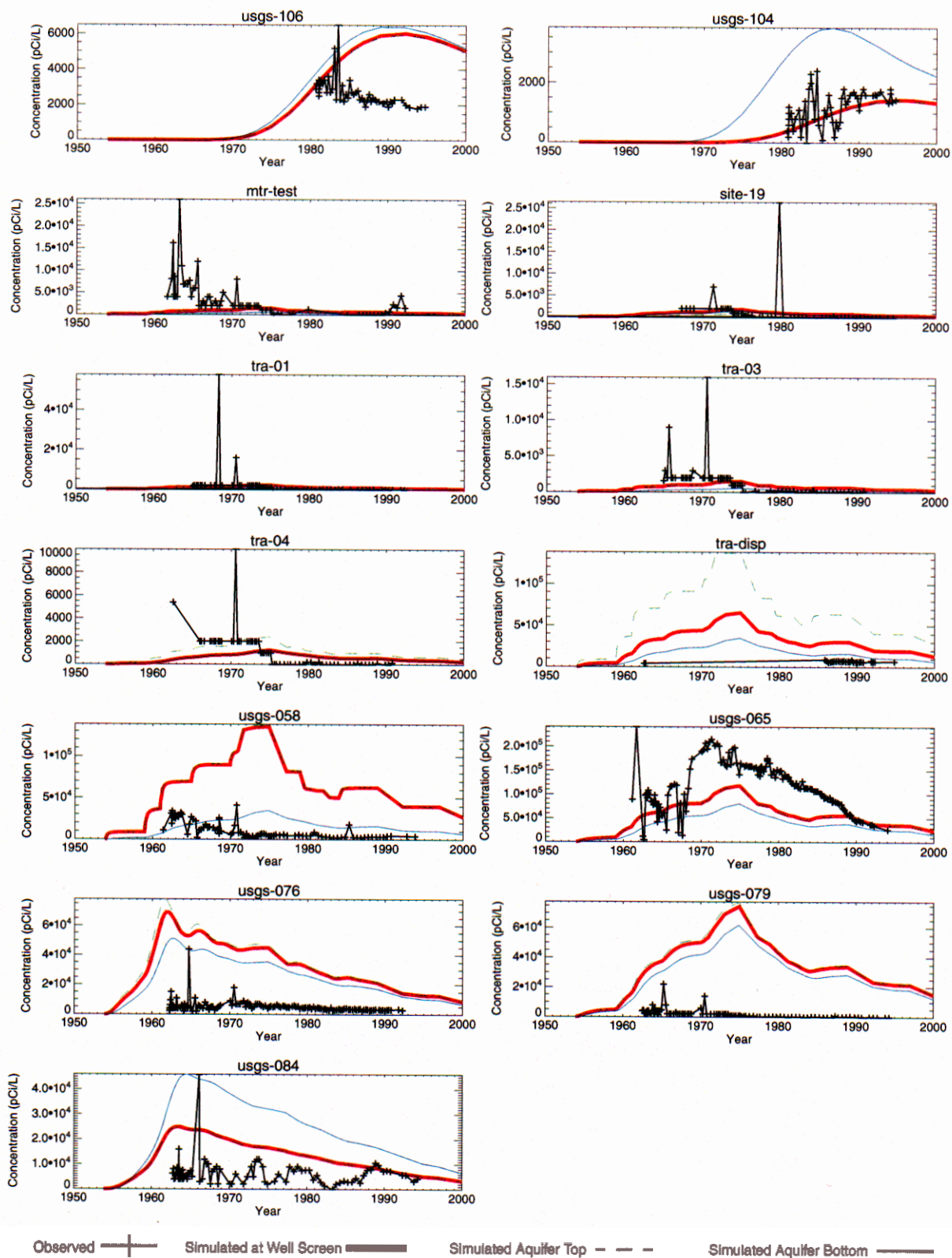**Figure 4-14 continued** Comparison of simulated and measured H-3 concentrations.

Observed ——|—— Simulated at Well Screen ▬▬▬ Simulated Aquifer Top – – – Simulated Aquifer Bottom ———

Figure 4-14 continued Comparison of simulated and measured H-3 concentrations.

4.2.5 Plutonium-241

Pu-241 concentrations **exceeded the 0.145 pCi/L** 10^{-6} risk concentration twice during the period 1959 through 1986, but always remained below the 63 pCi/L MCL during the simulation period. The RI/BRA analysis predicted the highest aquifer total plutonium concentrations would be a result of the vadose zone tank farm contamination and the peak aquifer concentration would occur in the year 3585. However, the short half-life of Pu-241 (14.4 years) and large K_d (20 ml/g) would result in the majority of the vadose zone Pu-241 decaying before entering the aquifer. Figure 4-15 illustrates peak aquifer concentrations anywhere in the aquifer. A comparison of simulated and observed because Pu-241 has not been reported in the aquifer.
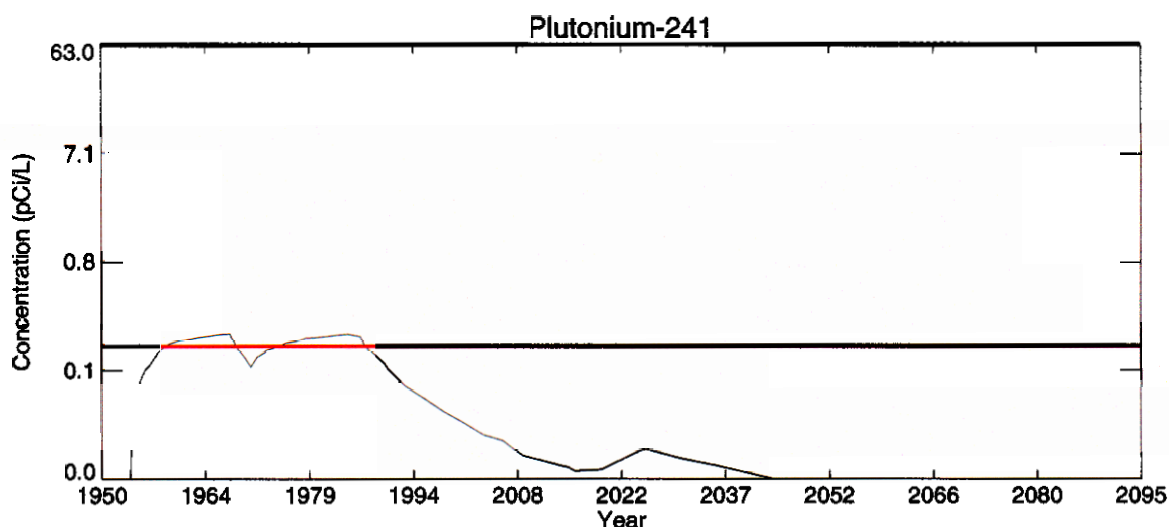

Figure 4-15 Peak aquifer concentration for Pu-241 (log scale, red line is 10^{-6} risk and blue line is MCL concentration).

4.2.6 Strontium-90

Sr-90 concentrations exceeded the 0.86 pCi/L 10^{-6} risk concentration from 1959 through the simulation period and remained above the 8 pCi/L MCL from 1959 through 2019. Figure 4-16 illustrates peak concentrations anywhere in the aquifer and Figure 4-17 compares simulated and measured Sr-90 concentrations in aquifer monitoring wells. The model both overpredicted and underpredicted aquifer concentrations, but underpredicted concentrations more often than not, lending more evidence that estimating fractured basalt sorption coefficients from 1/25 the sediment may overestimate the K_d value.
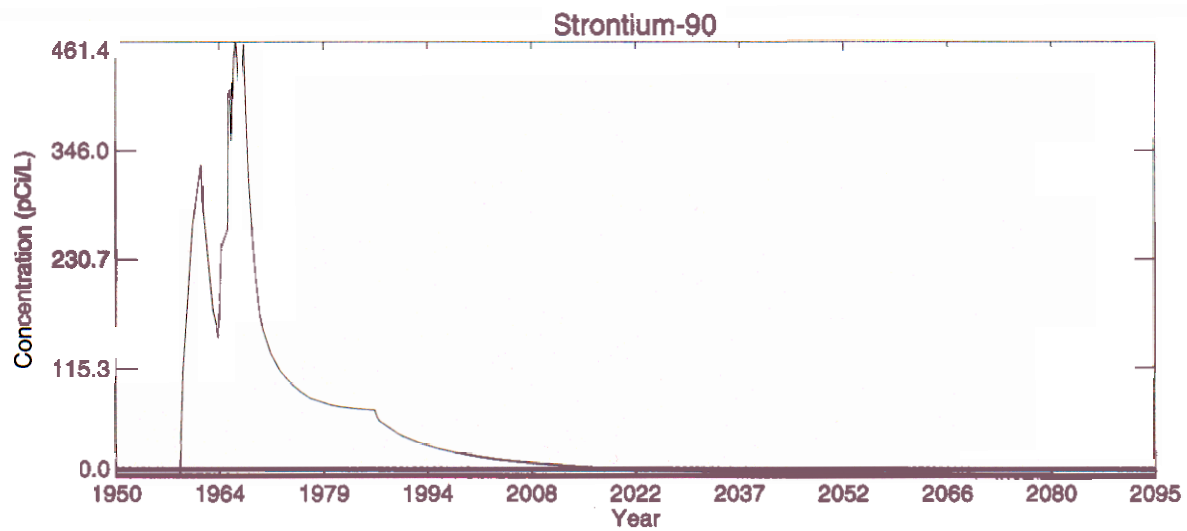
Figure 4-16 Peak aquifer concentration for Sr-90 (red line is 10^{-6} risk and blue line is MCL concentration).

Figure 4-17 Comparison of simulated and measured Sr-90 concentrations.

Figure 4-17 continued Comparison of simulated and measured Sr-90 concentrations.

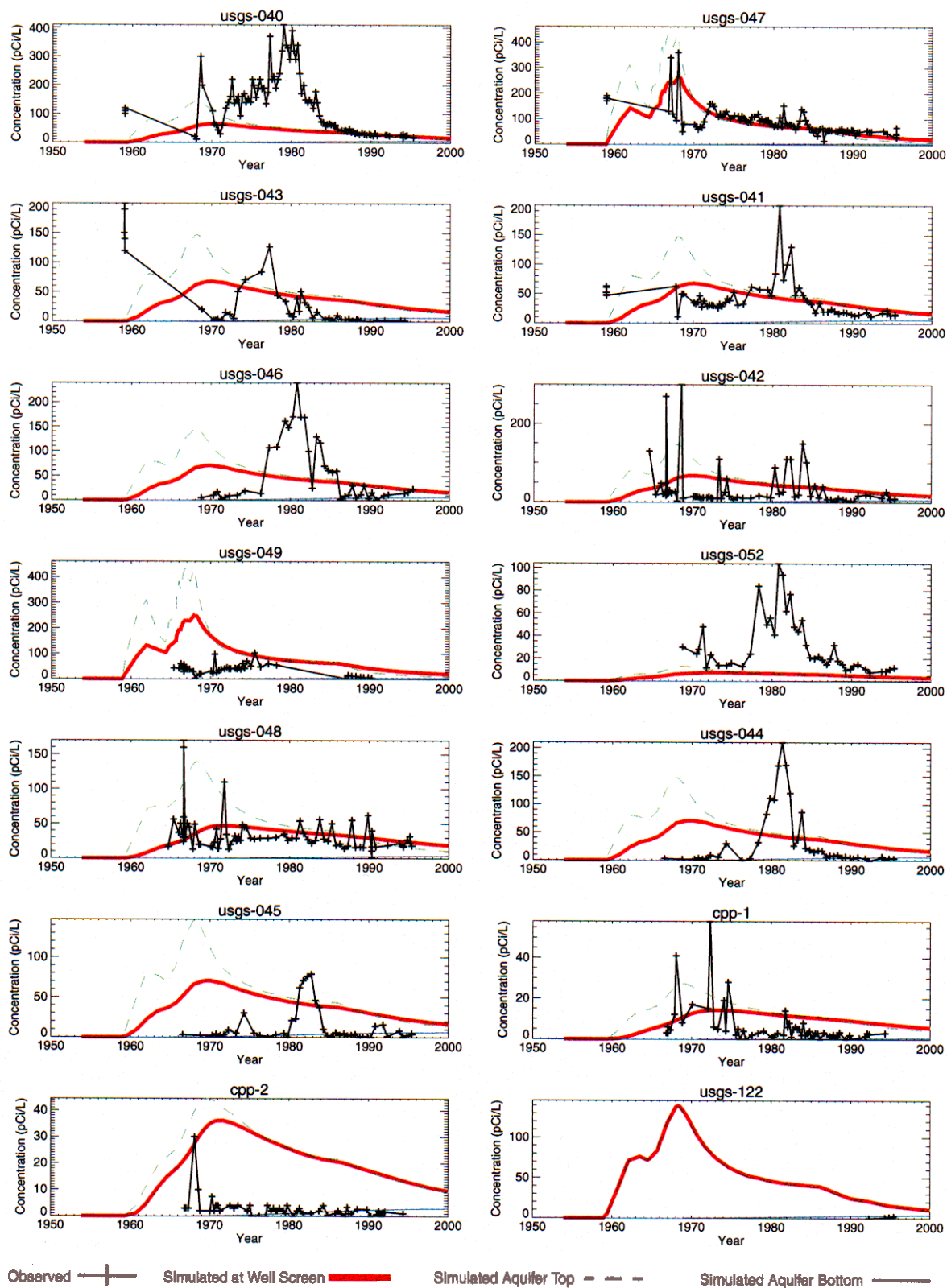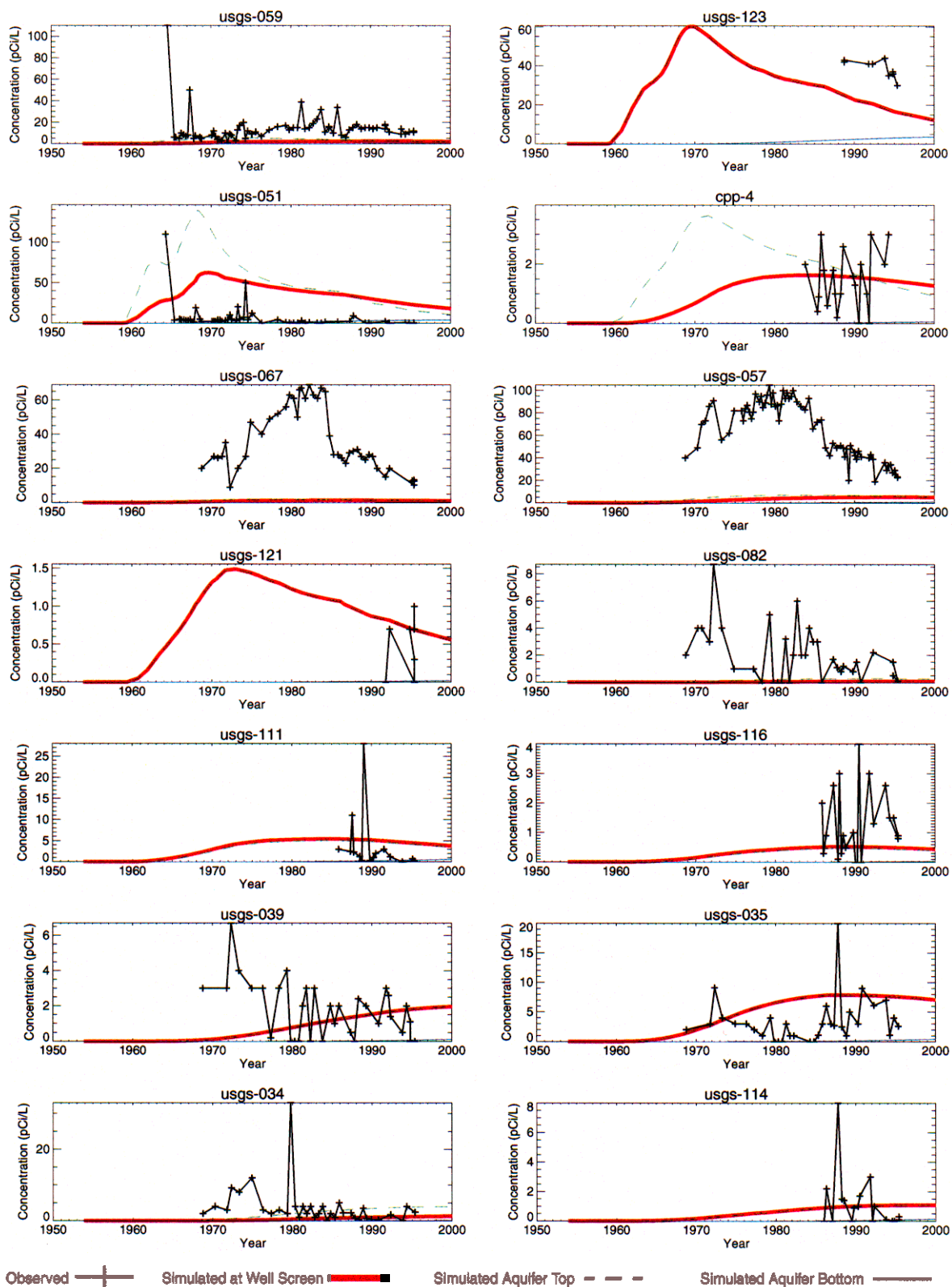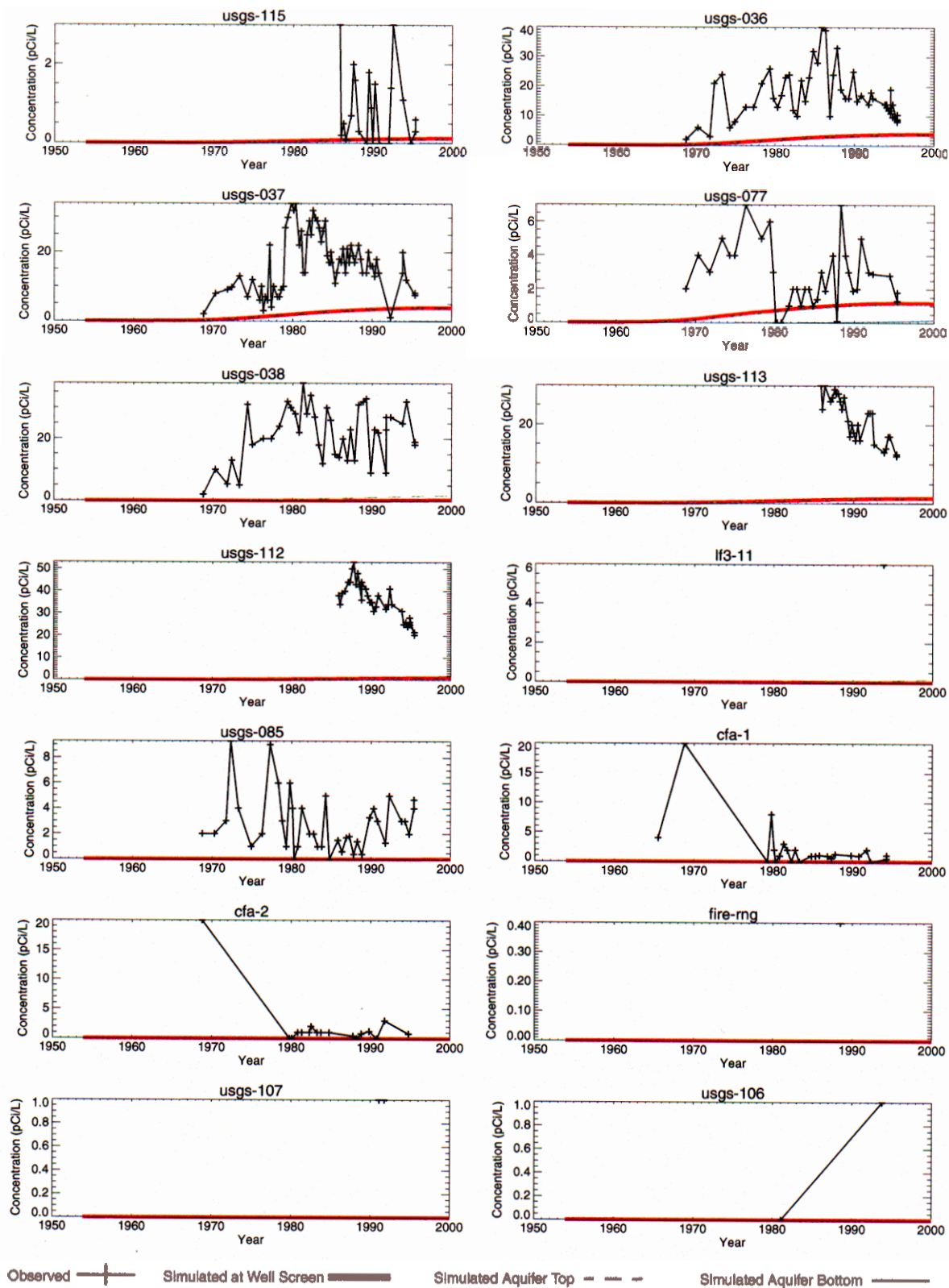**Figure 4-17 continued** Comparison of simulated and measured Sr-90 concentrations.
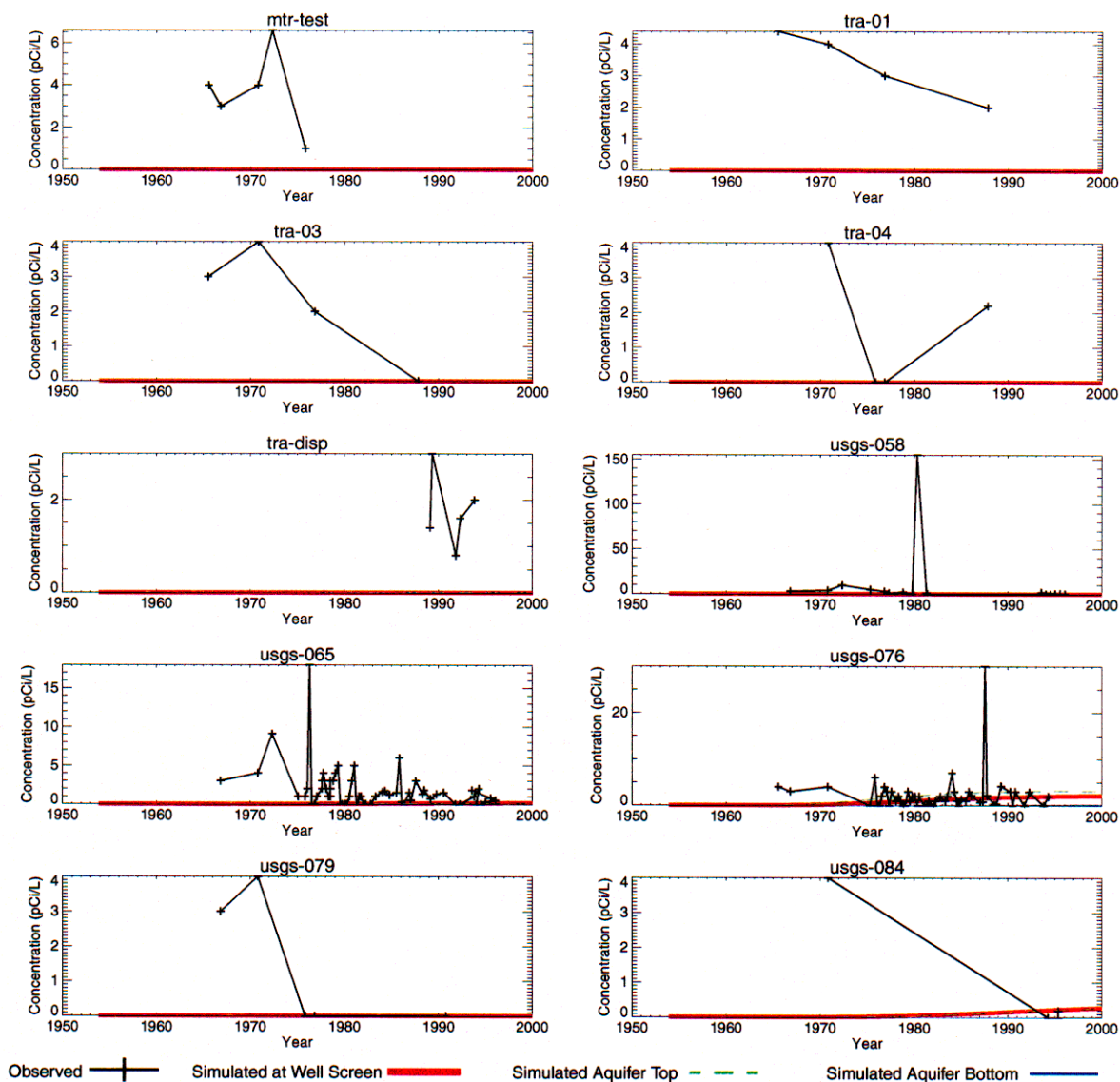
Figure 4-17 continued Comparison of simulated and measured Sr-90 concentrations.

4.2.7 Technetium-99

Tc-99 concentrations remained below the 34 pCi/L 10^{-6} risk and the 900 pCi/L MCL concentrations throughout the simulation period. Figure 4-18 illustrates peak aquifer concentrations anywhere in the aquifer and Figure 4-19 compares simulated and measured concentrations in aquifer monitoring wells. As with Sr-90, the model underpredicted aquifer concentrations more often than overpredicted aquifer concentrations, which again suggests the partition coefficients were overestimated. There is very little Tc-99 data and all measured concentrations were below MCL. All measured concentrations were also below the 10^{-6} risk concentration with the exception of wells USGS-47 and USGS-52.
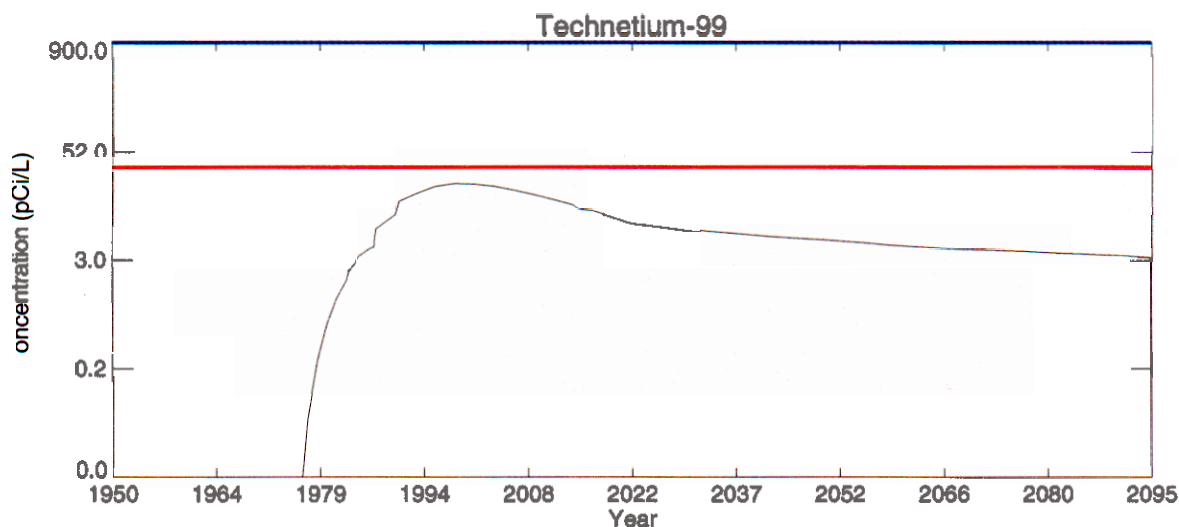

Figure 4-18 Peak aquifer concentration for Tc-99 (log scale, red line is 10^{-6} risk and blue line is MCL concentration).
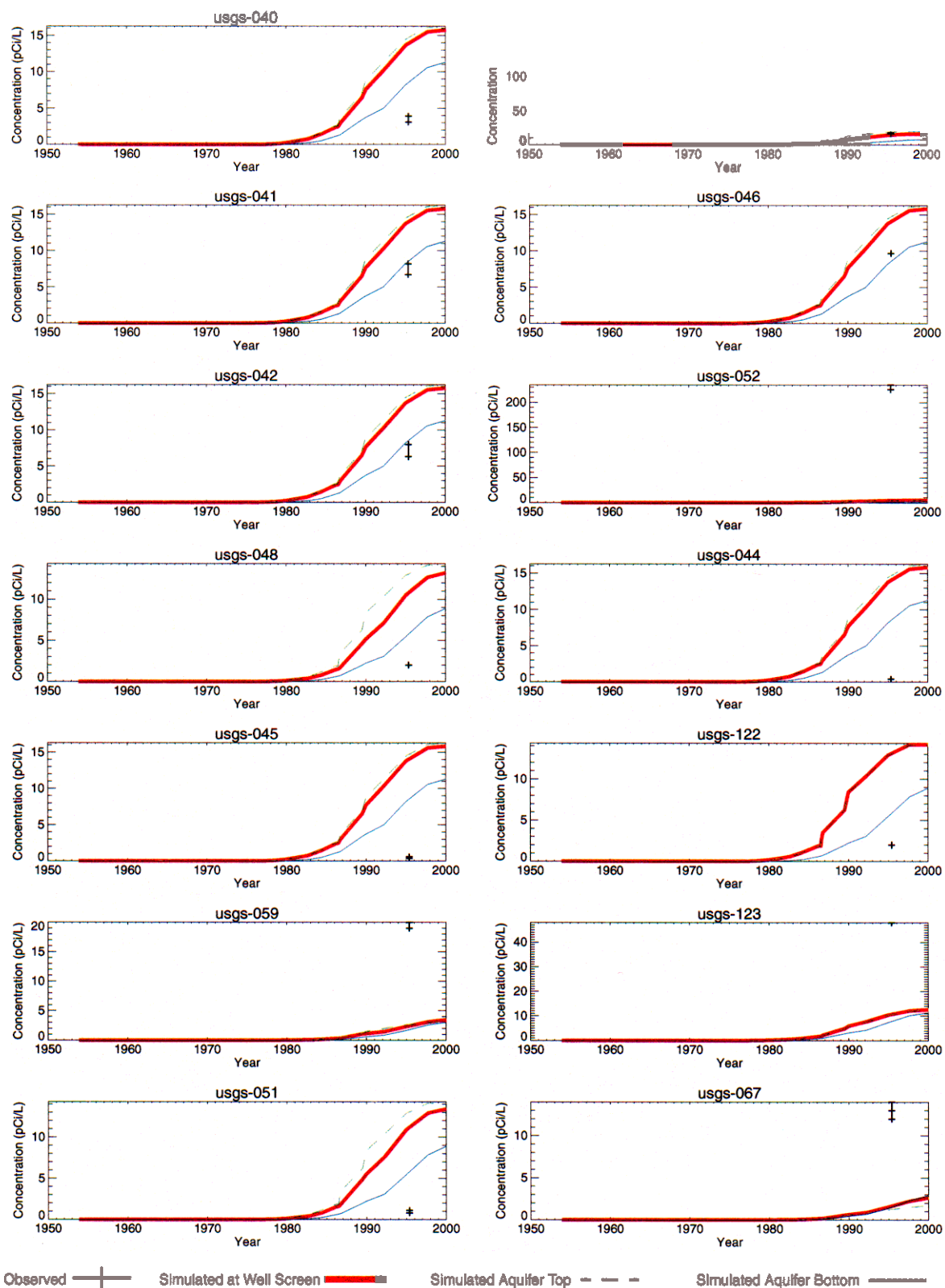
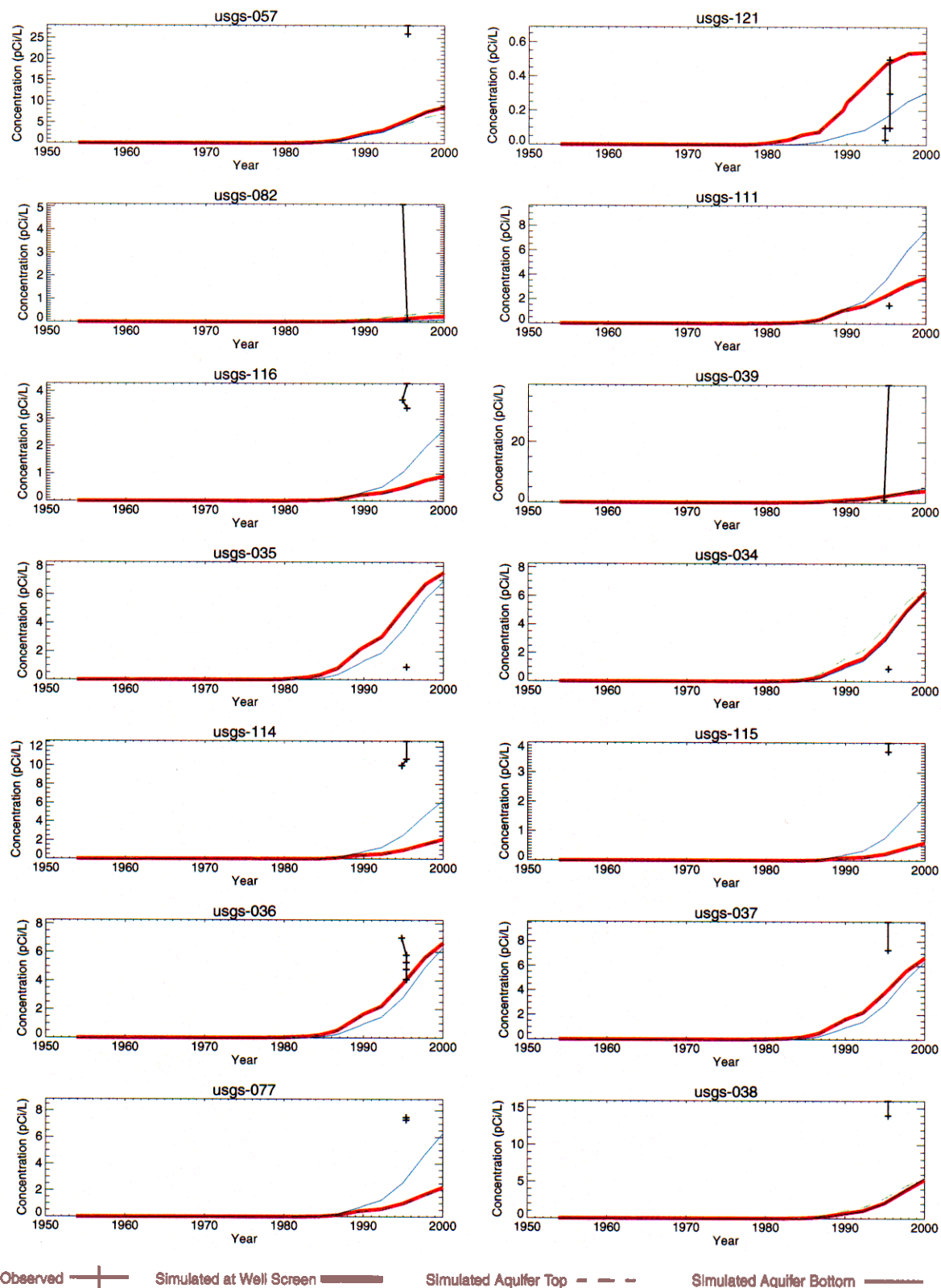**Figure 4-19** Comparison of simulated and measured Tc-99 concentrations.

Figure 4-19 continued Comparison of simulated and measured Tc-99 concentrations.
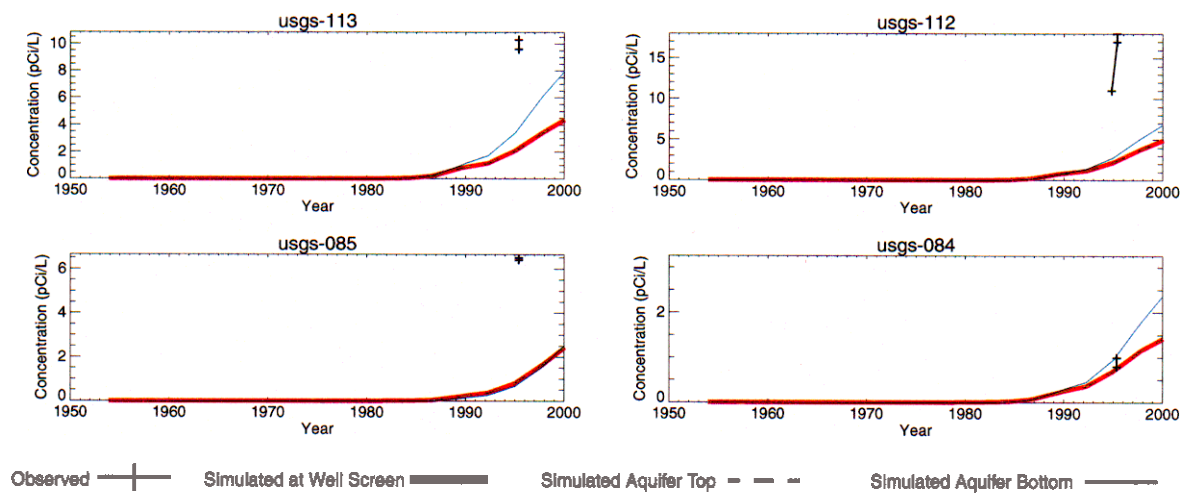
Figure 4-19 continued Comparison of simulated and measured Tc-99 concentrations.

4.2.8 Predictive Simulation Summary

Six out of the seven simulated COPCs had concentrations above the 10^{-6} risk concentration at some time between 1954 and 2095, and three contaminants had concentrations above the MCL. I-129, Co-60, Cs-137, H-3, Pu-241, and Sr-90 all had concentrations above the 10^{-6} risk concentration. I-129, H-3, and Sr-90 had concentrations above the MCL concentration. Table 4-2 summarizes the predictive simulation results and presents the peak contaminant concentration, time of peak during simulation period, peak concentration in 2095, 10^{-6} risk concentration, and MCL concentration.

Tritium, Sr-90, and I-129 dominated the cumulative aquifer beta/gamma risk. Figure 4-20 illustrates the cumulative aquifer risk at the southern INTEC fence line for all simulated COPCs. The black line in Figure 4-20 illustrates cumulative risk over time and the red, blue, and green lines illustrate the individual risk from tritium, Sr-90, and I-129, respectively. Figure 4-21 illustrates the cumulative dose rate at the southern INTEC fence line.

Table 4-2 Predictive simulation peak aquifer concentrations.

| Contaminant	Peak Aquifer Concentration (pCi/L)	Time of Peak Aquifer Concentration (Year)	Peak Aquifer Concentration in 2095 (pCi/L)	10^{-6} Risk Concentration (pCi/L)	Federal Drinking Water Standard[*] (pCi/L)
Iodine 129 (I-129)	17.6	1979	0.99	0.261	1.0
Cobalt 60 (Co-60)	8.76	1968	0.023 in 2063***	2.54	100.
Cesium 137 (Cs-137)	52.4	1966	0.85	1.52	200.
Tritium (H-3)	1.06e+6	1964	7.21	671.	20,000.
Plutonium 241 (Pu-241)	0.186	1967	0.003	0.145	63.**
Strontium 90 (Sr-90)	461.	1966	2.01	0.859	8.
Technetium 99 (Tc-99)	22.5	1997	3.22	34.3	900.
*Based on the 4 mrem/yr critical organ dose as listed in the National Bureau of Standards Handbook 69 (HB69) and 2l/d 365d/yr consumption rate.					
**Not listed in HB69. 1991 proposed limits at 4 mrem/yr effective dose equivalent, which corresponds to 4.66e-6 risk.					
***Simulation ended before 2095.					
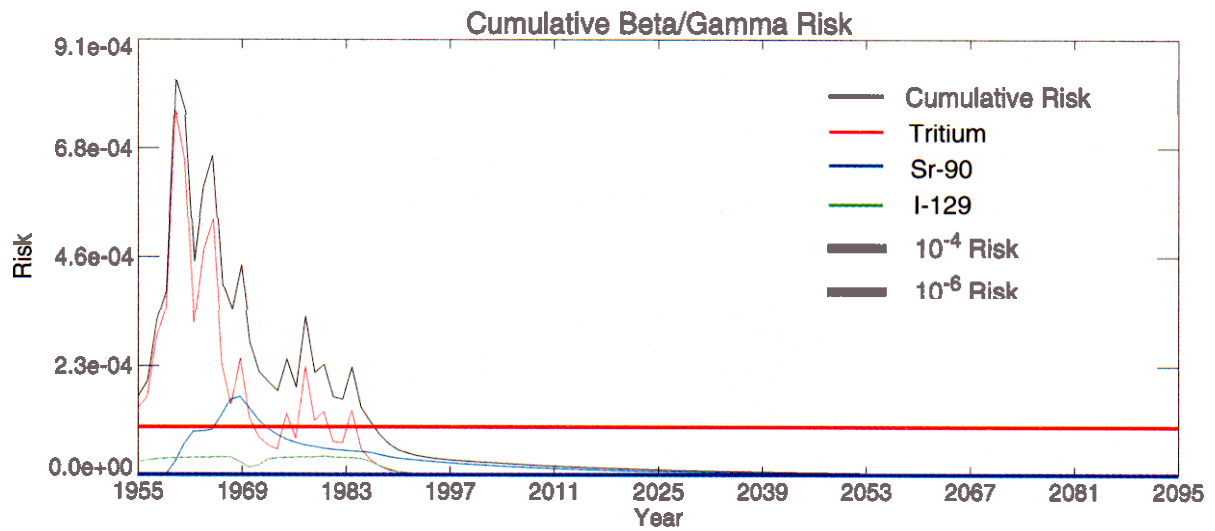
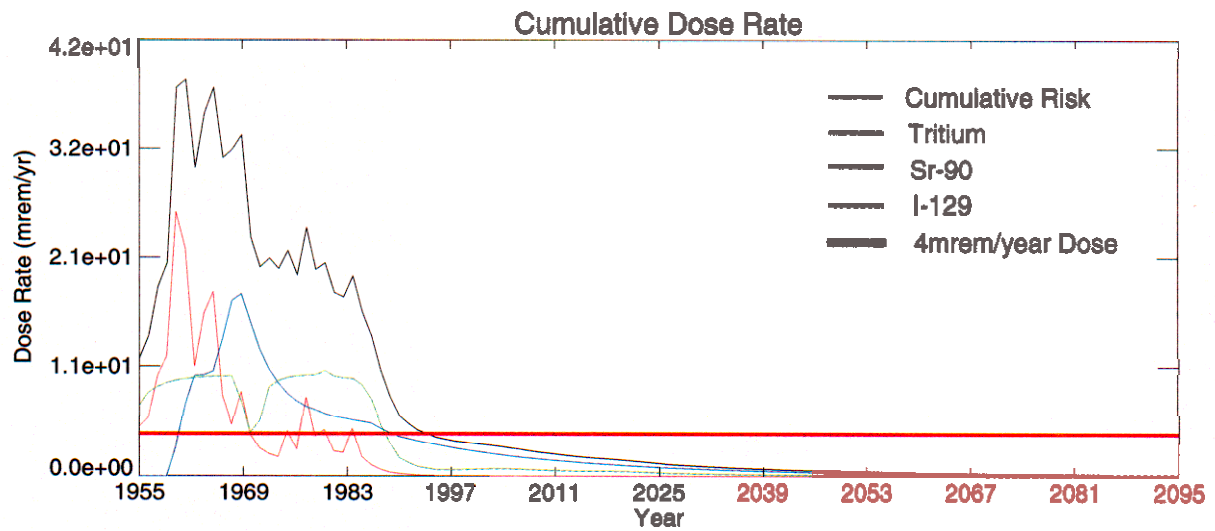**Figure 4-20** Cumulative risk for all simulated COCs.

Figure 4-21 Cumulative dose rate for all simulated COCs.

5 MODELING DATA NEEDS

Contaminant concentration data in the aquifer basalt and HI interbed are needed to verify whether modeling is correctly simulating the interaction of the basalt and HI interbed. At this time, elevated I-129 and other contaminant concentrations in the interbed are hypothetical and are based on modeling. Answering this data need can best be accomplished by gathering a vertical profile of aquifer concentrations above, within and below the HI interbed at several locations. The area immediately south of the INTEC percolation ponds and the area near the Central Facilities Area are of particular interest because these areas are predicted to have elevated HI interbed I-129 concentrations now and retain these high concentrations in the year 2095.

The areal extent of contamination in the year 2095 was very sensitive to permeability in both the rediscretized and RI/BRA models, thereby indicating interbed permeability on a field scale at several locations is needed to verify the RI/BRA model's homogeneous 4 mD (0.01 ft/d) and the recalibrated model's 70 mD (0.17 ft/d) HI interbed permeability. HI interbed permeability investigations should not be limited to evaluation of retrieved core because hydrological properties of INEEL core rarely represent INEEL conditions on a field scale. The most useful HI interbed permeability measurements would be obtained from a straddle packer type pumping test of the insitu HI interbed.

Additional HI interbed elevation, interbed thickness, aquifer thickness data are also needed. However, it may not be feasible to gather enough data to adequately describe the HI interbed elevation, interbed thickness, and aquifer thickness with statistical confidence because of the variability of the data and the large area of interest.

There also is a need for better partition coefficients for the contaminants that interact chemically with the aquifer matrix. The RI/BRA analysis was very conservative and probably underestimated the sediment values, but may have overestimated the fractured basalt values. The fractured basalt partition coefficients were estimated from 1/25 of the sediment value and the result may have been to overestimate the amount attenuation from sorption in the aquifer. The approach used by the WAG-7 preliminary RI/BRA modeling (Magnuson and Sondrup, 1998) to estimate fracture basalt K_d values should be used to evaluate WAG-3 contaminant K_d values. Magnuson and Sondrup calculated fractured basalt contaminant K_ds from fracture surface area rather than the mass of the rock matrix, because the contaminant's chemical interaction with the rock is a surface area phenomena.

6 MODELING PATH FORWARD

In the event that sampling of the Snake River Plain Aquifer HI interbed indicates I-129 concentrations significantly exceed the specified action level of 11.4 pCi/L, characterization of the HI interbed should be performed. Data gathered during the characterization effort should be incorporated into the updated model and the model should be used to reassess long term risk and help guide remediation efforts.

The modeling presented in this document represents a first effort in refining the RI/BRA model to more accurately represent the Snake River Plain Aquifer and the interaction of contaminants with the aquifer's HI interbed. However, the model calibration is not complete and needs to incorporate contaminant sampling and characterization data from the HI interbed before predictive simulations can be relied upon. Furthermore, partition coefficients for the fractured basalt need to be reassessed.

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